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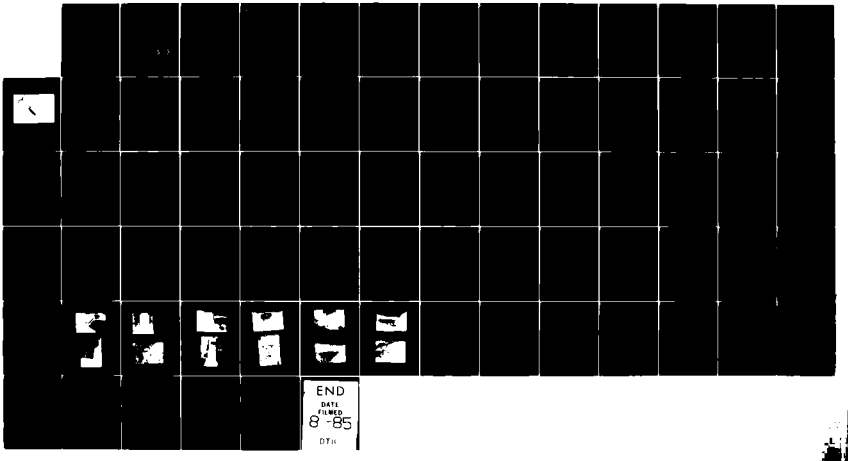

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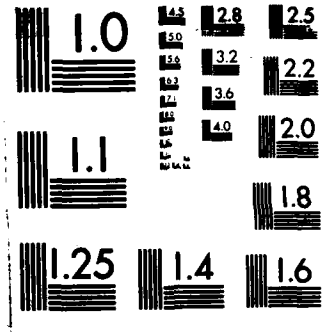
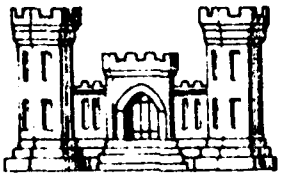


CONNECTICUT RIVER BASIN
BETHLEHEM NEW HAMPSHIRE

BETHLEHEM DAM
N.H.00279

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM



DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

APRIL, 1979

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02154

REPLY TO
ATTENTION OF:
NEDED

OCT 2 1979

Honorable Hugh J. Gallen
Governor of the State of New Hampshire
State House
Concord, New Hampshire 03301

Dear Governor Gallen:

I am forwarding to you a copy of the Bethlehem Dam Phase I Inspection Report, which was prepared under the National Program for Inspection of Non-Federal Dams. This report is presented for your use and is based upon a visual inspection, a review of the past performance and a brief hydrological study of the dam. A brief assessment is included at the beginning of the report. I have approved the report and support the findings and recommendations described in Section 7 and ask that you keep me informed of the actions taken to implement them. This follow-up action is a vitally important part of this program.

A copy of this report has been forwarded to the Water Resources Board, the cooperating agency for the State of New Hampshire. In addition, a copy of the report has also been furnished the owner, Dr. Arnold Polonsky, Bethlehem, New Hampshire 03574.

Copies of this report will be made available to the public, upon request, by this office under the Freedom of Information Act. In the case of this report the release date will be thirty days from the date of this letter.

I wish to take this opportunity to thank you and the Water Resources Board for your cooperation in carrying out this program.

Sincerely,

MAX B. SCHEIDER
Colonel, Corps of Engineers
Division Engineer

Incl
As stated

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER NH 00279	2. GOVT ACCESSION NO. AD-A156373	3. RECIPIENT'S CATALOG NUMBER
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18. SUPPLEMENTARY NOTES

Cover program reads: Phase I Inspection Report, National Dam Inspection Program; however, the official title of the program is: National Program for Inspection of Non-Federal Dams; use cover date for date of report.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

DAMS, INSPECTION, DAM SAFETY,

Connecticut River Basin
Bethlehem, New Hampshire
Lower Ammonoosuc River

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The dam is a run of the river dam with a concrete spillway and earth embankments with concrete core wall at the abutments. The overall length of the dam is 282 ft. and it has a maximum height of 29 ft. It is small in size with a low hazard potential classification. The dam was judged to be in fair condition. The owner should implement a program of annual periodic technical inspection and maintenance.

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BETHLEHEM DAM

NH00279

BETHLEHEM, NEW HAMPSHIRE

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

NATIONAL DAM INSPECTION PROGRAM
PHASE I INSPECTION REPORT

Identification No:	NH00279
Name of Dam:	Bethlehem Dam
Town:	Bethlehem
County and State:	Grafton County, New Hampshire
Stream:	Lower Ammonoosuc River
Date of Inspection:	November 14, 1978

BRIEF ASSESSMENT

The Bethlehem Dam is a run-of-the-river dam with a concrete spillway and earth embankments with concrete core wall at the abutments. The overall length of the dam is 282 feet and it has a maximum height of 29 feet. The dam is no longer serving its original purpose, but the current owner is investigating restoring the dam for hydroelectric power. The drainage area is 96.1 square miles and the normal impoundment surface area is approximately 5.5 acres.

Based on a size classification of small and a hazard classification of low, in accordance with "Recommended Guidelines for Safety Inspection of Dams, Department of the Army, November 1976" the test flood for this dam is the 100-year return flood. Because of the limited storage the test flood outflow is equal to the test flood inflow. The test flood of 16,890 CFS overtops the spillway wingwalls and abutments by 0.4 feet. The spillway has a capacity without overtopping of 91.7 percent of the test flood.

The dam is judged to be in fair condition. The following significant conditions were observed:

1. Significant erosion and deterioration were observed at the earth embankments and core walls at both abutments.

2. Extensive siltation was found inside the hollow compartments of the spillway, restricting the operation of the base slab drains.

3. The condition of the gate house constitutes a dangerous environment to trespassers.

A detailed assessment and recommendations for remedial measures are contained in Section 7. In summary, it is recommended that the following actions be taken under the guidance of a qualified engineer within one year of the receipt of this report:

1. Repair the core walls and replace embankment material to original grades.

2. Remove the silt from the interior compartments and determine its origin.

3. Repair or replace the waste gate.

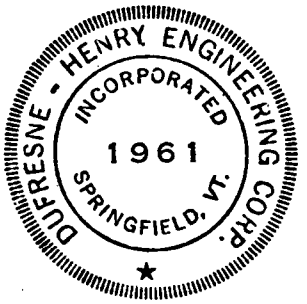
In addition, the owner should implement a program of annual periodic technical inspection and maintenance including the following items:

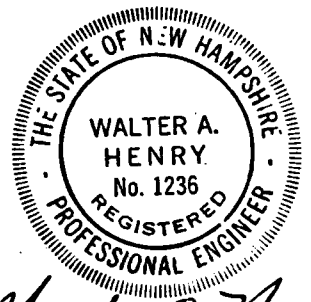
1. Remove trees from earth embankments.

2. Prevent access to the gate house.

3. Maintain gates in operable condition.

4. Repair and patch cracked and spalled concrete.





Walter A. Henry

This Phase I Inspection Report on Bethlehem Dam has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgment and practice, and is hereby submitted for approval.

JOSEPH W. FINEGAN, JR., MEMBER
Water Control Branch
Engineering Division

JOSEPH A. MCELROY, MEMBER
Foundation & Materials Branch
Engineering Division

CARNEY M. TERZIAN, CHAIRMAN
Chief, Structural Section
Design Branch
Engineering Division

APPROVAL RECOMMENDED:

JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigations, and analyses involving topographic mapping, subsurface investigations, testing and detailed computational evaluations are beyond the scope of a Phase I Investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test Flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

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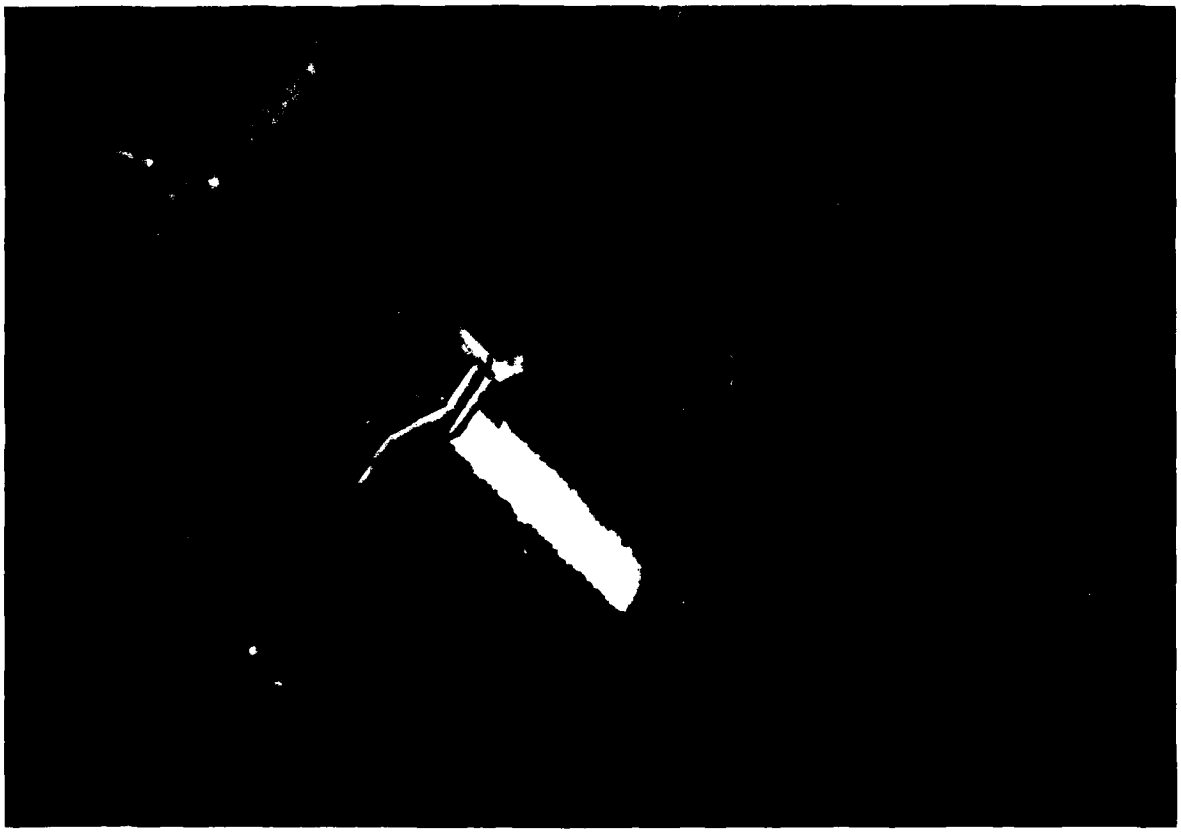
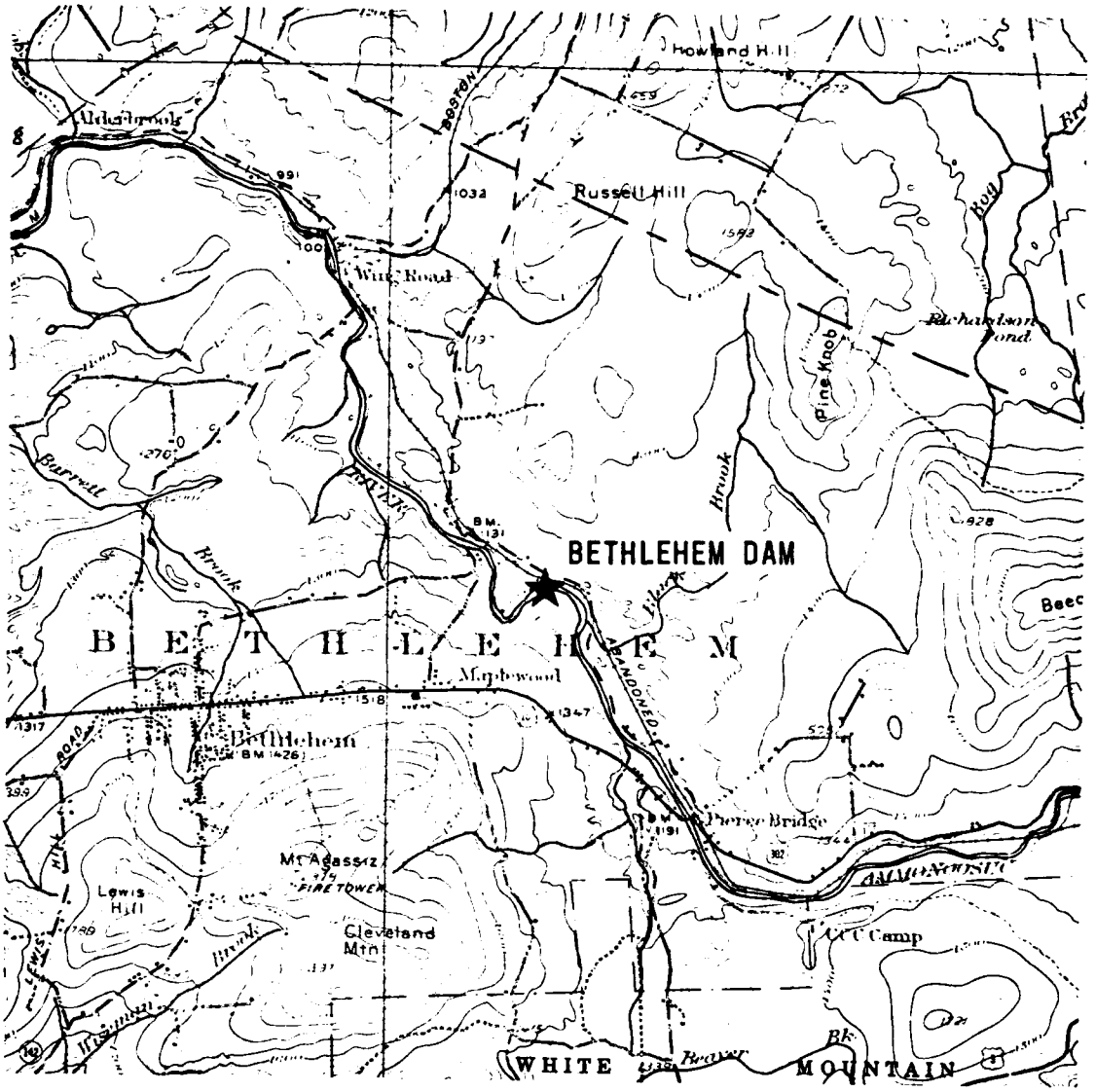


OVERVIEW OF
BETHLEHEM DAM
BETHLEHEM, NEW HAMPSHIRE



SOURCE OF MAP:
U.S. GEOLOGICAL QUADRANGLE
WHITEFIELD, N.H., VT.
1:62500 1935

DUFRESNE-HENRY ENGINEERING CORP. ARCHITECT-ENGINEER	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

LOCATION MAP
BETHLEHEM DAM

BETHLEHEM NEW HAMPSHIRE

CLIENT NO	04-0087		SCALE 1" = 1 MILE
ENGR	JAD		DATE APRIL, 1979

NATIONAL DAM INSPECTION PROGRAM
PHASE I INSPECTION REPORT
NAME OF DAM: BETHLEHEM

SECTION 1 - PROJECT INFORMATION

1.1 General

a. Authority

Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a National Program of Dam Inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. Dufresne-Henry Engineering Corporation has been retained by the New England Division to inspect and report on selected dams in the State of New Hampshire. Authorization and notice to proceed were issued to Dufresne-Henry Engineering Corporation under a letter of November 20, 1978 from Max B. Scheider, Colonel, Corps of Engineers. Contract No. DACW33-79-C-0010 has been assigned by the Corps of Engineers for this work.

b. Purpose

(1) Perform technical inspection and evaluation of non-federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by nonfederal interests.

(2) Encourage and prepare the states to initiate quickly effective dam safety programs for nonfederal dams.

(3) To update, verify and complete the National Inventory of Dams.

1.2 Description of Project

a. Location

The Bethlehem Dam is located in northern New Hampshire, in the Town of Bethlehem, Grafton County. The dam is on the Lower Ammonoosuc River which is in the Connecticut River Basin.

b. Description of Dam and Appurtenances

The Bethlehem Dam has an overall length of 282 feet and a maximum height of 29 feet. The main components of the dam include a reinforced concrete spillway and earth embankments with concrete core walls at each abutment.

The dam is 29 feet high and was originally constructed for the generation of power. Water impounded by the dam was piped through a 72-inch steel penstock to a power house located approximately 1000 feet downstream where the available head is 45 feet.

The gate works, located on the right river bank include a penstock head gate and a waste gate.

The dam was originally equipped with 4-foot flashboards. The 4-inch diameter pipe support inserts are visible across the dam crest, but there is no evidence of the boards or vertical supports.

c. Size Classification

The Bethlehem Dam has a maximum height of 29 feet and an estimated maximum storage of 116 acre-feet. In accordance with the guidelines, dams with maximum storage between 50 and 1000 acre-feet and/or maximum height between 25 and 40 feet are sized as small. Therefore the Bethlehem Dam is classified as small.

d. Hazard Classification

A failure of the Bethlehem Dam would route a flood wave into the lower river channel. Because of the relatively small storage volume and natural channel constriction immediately downstream of the dam, any flood wave produced would easily be contained within the river banks. Therefore, the hazard classification of the Bethlehem Dam is low.

e. Ownership

The present owner of the Bethlehem Dam is:

Dr. Arnold Polonsky
Bethlehem
New Hampshire 03574

The previous owner was the Public Service Company of New Hampshire.

f. Operator

At the present time there is no regular operation or maintenance being performed on the dam. The responsibility for operation of the dam lies with the owner, Dr. Arnold Polonsky, telephone 603-444-2453.

g. Purpose

The Bethlehem Dam is no longer serving its original purpose. A study by the owner is currently under way investigating the possibility of restoring the dam for private power generation.

h. Design and Construction History

The present reinforced concrete dam is an Ambursen type dam, built by the Ambursen Construction Company in 1926. The dam was a replacement for an earlier log crib dam which impounded water for a hydroelectric power house located 1000 feet downstream.

The spillway section is composed of nine hollow chambers, accessible from both concrete abutments. A catwalk located 5 feet above the chamber floors runs the entire length of the spillway to allow inspection of the interior. The chambers are drained by small openings located at the toe of the spillway. A concrete energy dissipator forms an integral part of the concrete spillway and has been effective in preventing washout of the downstream foundation material. The plans found in Appendix B have been drawn from visual observation and data on file with the New Hampshire Water Resources Board including design drawings.

The dam has not undergone any significant structural change since the original construction.

i. Normal Operational Procedure

The dam is not being operated at the present time. The waste gate is inoperable in the closed position.

1.3 Pertinent Data

a. Drainage Area

The drainage basin of the Bethlehem Dam encompasses approximately 96 square miles of variable terrain from rolling hills along Routes 3 and 302 to the mountainous terrain of the White Mountain National Forest.

The predominant soils are glacial till with hardpan or bedrock within three feet of the surface.

b. Discharge at Dam Site

At the present time the discharge at the site includes only the overflow spillway. A penstock head gate and waste gate

are inoperable and in the closed position. No records nor recollections of any flooding could be found for this dam site.

Spillway capacity at top of dam - 15,480 CFS.

c. Elevations

(1) Streambed at Centerline of Dam

1115.

(2) Maximum Tailwater

Variable.

(3) Upstream Portal Invert

Not applicable.

(4) Recreation Pool

1135 ±.

(5) Full Flood Control Pool

Not applicable.

(6) Spillway Crest

1134.6.

(7) Design Surcharge

1143.6.

(8) Top of Dam

1143.6

(9) Test Flood Elevation

1144.

d. Reservoir	Feet*
Length of Maximum Pool	2800

*Estimated based on aerial photographs, USGS maps and estimated average water depths.

	Feet *
Length of Recreation Pool	1700
Length of Flood Control Pool	Not applicable.

e. Storage

	Acre-Feet *
Recreation Pool	22
Flood Control Pool	Not applicable.
Test Flood Pool	116
Spillway Crest Pool	22
Top of Dam	116

f. Reservoir Surface

	Acres *
Top Dam	9
Test Flood Pool	9
Flood-Control Pool	Not applicable.
Recreation Pool	5.5
Spillway Crest	5.5

g. Dam

(1) Type

Run-of-river dam consisting of earth embankments with concrete core walls adjoining a 140-foot Ambursen concrete spillway.

(2) Length

282 feet overall; 140 feet spillway.

(3) Height

20 feet (concrete spillway; 29 feet (top of training walls).

(4) Top Width

Earth embankments eroded below top of core wall.

(5) Side Slopes

Earth Embankments - Upstream 2:1
Downstream 2:1
Concrete Spillway - Upstream 1:1
Downstream - variable

* Estimated based on aerial photographs, USGS maps and estimated average water depths.

(6) Zoning

None known.

(7) Impervious Core

Concrete core wall.

(8) Cutoff

Concrete footing.

(9) Grout Curtain

None known.

h. Diversion and Regulating Tunnel

Not applicable.

i. Spillway

The spillway is a concrete Ambursen type spillway containing nine hollow compartments. The spillway is 140 feet long and 20 feet high from the streambed to the overflow crest. An energy dissipating apron is located at the toe of the spillway.

j. Regulating Outlets

The gate works located at the right abutment contain a head-gate for the trash rack and penstock to the old power house and a waste gate. Both gates are in the closed position and are inoperable due to rotting vertical members and lack of any mechanical lifting devices. The penstock head gate is 7 feet wide by 19.5 feet deep with an invert elevation of 89.5. The waste gate is 8 feet wide by 19.5 feet deep also with an invert elevation of 89.5.

SECTION 2 - ENGINEERING DATA

2.1 Design

Complete construction drawings were available for review during the investigation. The concrete spillway is an Ambursen design and consists of 9 hollow compartments, each 15'-6" in length. The interior of the dam contains a walkway located five feet above the floor slab. Each compartment contains base slab drains to relieve hydrostatic pressures and reduce uplift forces. Any water entering these drains flows out of the compartments via additional drains located at the base of the spillway (see cross-section on Plans).

2.2 Construction

Record data on file with the New Hampshire Water Resources Board includes several entries of correspondence and inspections during the construction of the dam. There was no data included which would affect the present safety of the dam.

The dam was completed in February 1926 and used 3855 cubic yards of concrete.

2.3 Operation

The dam is not being operated at the present time. Certain design features of the dam, namely the base slab drainage systems, were designed to operate without manual procedures. The operation of this drainage system is severely restricted by the excessive amount of sediment buildup within the spillway compartments. Without the drainage system, uplift forces may develop which might affect the stability of the structure. The origin of the sediment is also cause for concern. If the material is coming from the foundation soils, a serious condition may exist with the creation of voids, further reducing the dam's stability.

2.4 Evaluation

a. Availability

Construction drawings were available for review during the investigation.

b. Adequacy

The information obtained from the construction drawings and the visual observations are adequate to conclude that a potential problem exists. The problem cannot be verified

until the sediment is removed from the compartments, the operational status of the drains determined and the origin of the sediment established.

c. Validity

Not applicable.

SECTION 3 - VISUAL INSPECTION

3.1 Findings

a. General

The on-site inspection of the Bethlehem Dam was performed on November 14, 1978. Weather conditions were cloudy with the temperature in the mid-40s. Water was flowing over the spillway section of the dam, somewhat hampering the visual observation of the dam. No emergency conditions were observed on the day of inspection.

b. Dam/Spillway

The concrete spillway was found to be in generally good condition based on a limited visual inspection. The downstream face of the spillway shows some signs of erosion, especially at the construction joints between the compartment sections (see Photos 2 and 11).

A dark area can be seen on the downstream face of the first compartment from the right just below the crest (see Photo 5). This area indicates a smoother surface and may be a repair patch applied in the past. Anchor bolts and plates found in the interior of the first compartment support this assumption.

As described in Section 1.2.h, the concrete spillway consists of nine hollow compartments. The compartments are connected by a passageway and walkway. This design feature offered a unique opportunity to inspect the dam from its interior. The interior of the dam appeared to be in good condition with the exception of the far righthand compartment, where the concrete is extensively spalled in several locations, exposing the reinforcing steel (see Photo 4).

Photo 4 also shows two anchor plates and bolts which appear to be anchoring something on the downstream face of the dam. Photo 5 shows the downstream face of the compartment with a dark area located where the interior anchor plates were observed. It appears that the concrete in this area has a smoother texture and may be newer than the adjacent concrete. This could not be confirmed during the inspection because of the amount of water flowing over the dam.

During the inspection of the interior compartments, a considerable amount of fine sediment, up to 5 feet thick, was found in each compartment. The surface of the sediment slopes downstream. The origin of the sediment could not be determined during the initial visual inspection. Section 6

will discuss the sediment in more detail and assess possible structural implications.

c. Appurtenant Structures

(1) Core Walls

The right side core wall extends from the gate works into the right river bank. The wall is exposed for approximately 20 feet adjacent to the gate works. Earth embankment material has eroded and the core wall is spalling (see Photo 7).

The left core wall extends from the left wingwall into the left river bank and is exposed and badly spalled in several areas. It appears that the embankment material has been washed away leaving the core wall exposed to erosion and spalling. The remaining embankment is covered with trees and small brush (see Photo 8).

(2) Gate Works

The gate works, located at the right side of the spillway contain one head gate for the penstock and one waste gate. These gates are in the closed position and all lifting mechanisms have been removed. The vertical wooden members which contain the "rack" gear trains are rotting and could not be used to lift the gates.

Photo 6 shows the downstream side of the gate works and the sluiceway for the waste gate. A large leak can be seen at the lower left hand corner of the waste gate. The leak is occurring around the gate through spalled and eroded concrete.

The structural concrete of the building and training walls is in fair to poor condition. Extensive spalling is occurring on the training walls (see Photo 6) and the upstream faces of the foundation. The structural concrete of the superstructure is in good condition (see Photo 7).

All mechanical equipment plus doors, windows, railings, etc. have been removed from the building. This leaves the site open to trespassing and further damage from vandals. The inside of the building constitutes a dangerous environment because of the missing guard railings. Deep pits and channels are exposed and severe injury or loss of life could result if someone should fall into one.

d. Reservoir Area

The reservoir area is a wide section of the natural river channel (see Photos 10 and 12). The most significant aspect of the reservoir area is the amount of sediment in the impoundment pool. Normal water depths at the dam vary from 2 to 5 feet deep. This sedimentation has greatly reduced the storage volume of the reservoir.

e. Downstream Channel

Photo 9 shows a typical section of the downstream channel which is the natural river bed of the Ammonoosuc River. The river bends to the left just downstream of the dam and narrows considerably. Ice jamming occurs during the spring runoff in this area. Damage to trees on both banks indicates that the ice jamming is very extensive and often approaches the height of the dam.

3.2 Evaluation

The visual inspection did not disclose any immediate problems. The following findings, however, indicate areas of concern which may develop into problems in the near future:

a. The concrete in the far right hand compartment is showing signs of deterioration and has apparently been repaired at least once in the past.

b. The earth embankments at both abutments have been partially eroded away, exposing the concrete core walls which have undergone extensive deterioration.

c. The siltation inside the spillway compartment can impair the drainage of the foundation soils under the dam. According to the design drawings, drainage is intended through drain holes in the base of the dam with the purpose of reducing uplift pressures. Possible sources of the silt are:

(1) Inflow of water with silt through the vent and drains in the downstream apron at times when a sufficiently high tailwater may have developed as a result of ice jams downstream of the dam.

(2) Leakage of silty water through cracks in the upstream wall (deck) of the dam.

(3) Silty water coming through the foundation drains.

If the third mechanism were responsible for even a small fraction of the silt observed, it would indicate a very serious condition of development of voids in the foundation soils under the dam.

d. The gate works building has been vandalized and trespassing is extensive. The potential for accidental injury is high due to missing guard rails, broken glass and easy access.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 Procedures

None.

4.2 Maintenance of Dam

None.

4.3 Maintenance of Operating Facilities

None.

4.4 Description of Warning System

None.

4.5 Evaluation

The failure to remove the silt from the dam's interior compartments may have rendered the dam's underdrain system inoperable. This could lead to serious problems in the future. Under emergency conditions, it would be helpful if at least one of the gates were operational. The waste gate should either be made operational or replaced with a stop log sluiceway which could be removed more easily in the event of an emergency.

The safety of the gate works building should be improved by securing the building against trespassing. Windows should be replaced or bricked up and metal doors installed.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. General

The Bethlehem Dam has a concrete Ambursen type spillway, originally designed with four-foot flashboards, which have since been eliminated. The gate works contain two gates which are inoperable and cannot be used in determining hydraulic capacities.

b. Design Data

The original hydraulic and hydrologic design criteria were not available for this project.

c. Experience Data

The U. S. Geological Survey, in its summary paper of the 1927 flood, gives a flood flow of 17,900 CFS at the Bethlehem Dam. This flow would have overtopped the abutments by approximately 0.5 feet. A similar report on the 1936 storm lists maximum discharge and tailwater elevations based on water marks. Using a reported crest elevation of 1134.6 and the stage discharge diagram found in Appendix D, the 1936 storm was approximately 13,100 CFS at a stage height of 8.1 feet, which would not have overtopped the dam.

In 1939 a river gauge was installed at Bethlehem Junction located approximately 1.5 miles upstream of the Bethlehem Dam. The maximum flow recorded at that gauge was 10,800 CFS on October 24, 1959. Transferring this flow to the Bethlehem Dam by the six tenths ratio of their drainage area would result in a flow of 11,800 or a stage discharge of 7.8 feet.

d. Visual Observation

The reservoir has undergone extensive sedimentation since its construction. In particular, the south side of the reservoir is very shallow, averaging only 2 feet deep under normal conditions. At one location the sediment has exceeded the water level and a small island has been formed (see Overview Photo).

e. Test Flood Analysis

The dam is classified to be small with a low hazard rating. In accordance with the Guidelines, a 100-year recurrence flood was selected as the test flood for this study.

Record flow data was analyzed for USGS Gauge 01137500 located in Bethlehem Junction, approximately 1-1/2 miles upstream of the Bethlehem Dam. The record flow data was processed by computer in accordance with the "United States Water Resources Guidelines" (Bulletin 17). The results of the Bethlehem Junction gauge analysis were adjusted to the dam site by the ratio of their drainage areas to the six tenths power. This has resulted in a 100-year test flood at the dam of 16,890 CFS.

The spillway capacity of 15,480 CFS is 91.7 percent of the test flood. The test flood would result in the overtopping of the abutments of 0.40 feet.

f. Dam Failure Analysis

A failure of the Bethlehem Dam under normal flow conditions would produce an initial flood surge of 8,420 CFS. Because of the limited normal storage volume, the initial surge would quickly subside. Using the general rule of two-thirds the height of the dam, an initial flood wave of 13.2 feet would be produced, which would be contained within the 15-20 foot river banks.

Under flood conditions with the water elevation at the top of the abutments, the flow over the dam would be 12,700 CFS. A failure of the spillway would produce a breach of approximately 56 feet and an overall flow increase of 8,640 CFS. Because of the run-of-the-river characteristics and low storage, the breach surge would quickly subside.

Photo 12, the overhead photo and the location map indicate that downstream geometry would dampen any flood wave produced by a dam failure. Photo 12 shows that a channel constriction downstream of the dam would reduce a flood wave, in addition to creating a backwater effect on the dam. This was confirmed by eyewitnesses who have observed the dam under high flow conditions. The exact depth of the backwater could not be determined. Approximately 2000 feet downstream of the dam the river makes a sharp right hand bend. The combination of channel constriction and directional change would significantly reduce the flood wave energy (velocity). This reduction in energy may result in some overbank flow in a remote unpopulated area at the bend. The nearest dwellings are located 4,000 feet downstream and approximately 20 feet above the river bed. Any flood wave produced by a dam failure would be of minimal effect by the time it reached this location.

SECTION 6 - STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observation

The visual inspection did not disclose any immediate stability problems. However, the presence of the unusually large volume of silt inside the spillway compartments is cause for concern and additional investigation.

b. Design and Construction Drawings

The design drawings indicate that drainage holes connected to longitudinal drains under the slab were installed through the base slab of the hollow concrete gravity overflow section. Drawing 2525 of 7-28-1925 shows details of the underdrain system. The purpose of such drainage holes is to reduce the uplift water pressures. The effectiveness of the drains may be impaired by the accumulation of silt on the base slab. If the drains are not functioning as intended, the potential development of uplift pressures would severely decrease the degree of stability of the dam against sliding.

The origin of the silt buildup is also a potential stability problem. If the silt or a portion of the silt is coming from the base slab drains, voids could be forming under the dam. The voids would also decrease the stability of the dam to resist sliding.

c. Operating Records

There are no operating records available that are significant with respect to the stability of the dam.

d. Post-Construction Changes

There are no known post-construction changes affecting the stability of the dam.

e. Seismic Stability

The dam is located in Seismic Zone 2 and in accordance with USCE Recommended Phase I Guidelines does not warrant seismic analysis.

SECTION 7 - ASSESSMENT, RECOMMENDATIONS/ REMEDIAL MEASURES

7.1 Dam Assessment

a. Condition

The visual inspection indicated the dam to be in fair condition. However, as recommended in Section 7.2 the overflow section should be examined without water flowing over it.

There are no indications of problems affecting the immediate safety of the dam; however, the following features could adversely affect the safety in the future.

(1) Deterioration of the earth embankments at both abutments, particularly at the left abutment where a portion of the earth, downstream of the core wall, has washed away and the exposed core wall has spalled severely.

(2) The siltation of the spillway compartments is of concern for two reasons:

(a) The siltation is probably restricting the performance of the base slab drains.

(b) The origin of the silt needs to be investigated to determine whether it comes from the foundation soils.

b. Adequacy of Information

The visual inspection was limited because of the water flowing over the spillway. However, the data obtained during the inspection and the review of the plans provides adequate justification for the assessment and recommendations found in Section 7.2.

c. Urgency

The recommendations given in Section 7.2 should be carried out within one year after receipt of this report.

d. Need for Additional Investigations

There is no need for additional investigations beyond those recommended in Section 7.2

7.2 Recommendations

The following items should be performed under the guidance of a qualified engineer:

1. An additional visual inspection of the dam should be performed after lowering the water level upstream of the dam by opening the waste gate so that no water flows over the spillway. The spillway should then be inspected with attention to the condition of the concrete of the overflow section and to the foundation soils at the toe of the dam for indications of undermining and seepage.

2. The silt should be removed from the interior compartments and the base slab drains cleared of all obstructions. After removal of the silt from the interior compartments, a qualified engineer should investigate the origin of the silt and determine if any undermining of the dam has occurred.

3. Repair both core walls, removing and patching spalled areas and replacing the embankment material.

4. Repair or replace the waste gate.

7.3 Remedial Measures

a. Operating and Maintenance Procedures

1. Trees growing on the downstream slopes of the embankment should be removed, the eroded portion of the slope rebuilt to grade and a suitable grass or stone cover established to prevent future erosion.

2. Access to the gate house should be prevented to reduce the risk of accidents to trespassers.

3. A periodic annual technical inspection and maintenance program should be instituted that includes operation of the gates and inspection of the dam when there is no flow over the spillway. Routine maintenance should include cleaning and patching of spalled concrete and sealing of construction jointing with asphalt or epoxy-based sealants.

APPENDIX A

VISUAL INSPECTION CHECK LIST

VISUAL INSPECTION CHECK LIST
PARTY ORGANIZATION

PROJECT BETHLEHEM DAM DATE November 14, 1978

TIME _____

WEATHER Cloudy - 45°

W.S. ELEV. _____ U.S. ____ DN.S.

PARTY:

1. James H. Maynes D-H
2. James A. Dohrman D-H
3. Vern Clifford D-H
4. Gonzalo Castro GEI
5. Ken Stern, New Hampshire Water Resources Board
6. Chris Collman - Owner's Representative
7. _____
8. _____
9. _____
10. _____

PROJECT FEATURE	INSPECTED BY	REMARKS
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

PERIODIC INSPECTION CHECK LIST

PROJECT BETHLEHEM DAM DATE November 14, 1978

PROJECT FEATURE _____ NAME _____

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
DAM EMBANKMENT - CONCRETE SPILLWAY	*Water was flowing over spillway.
Crest Elevation	1134.6
Current Pool Elevation	1135 ±
Maximum Impoundment to Date	5.5 Acres ±.
Surface Cracks	None observed from surface (some cracks observed from inside of core).
Pavement Condition	Not applicable.
Movement or Settlement of Crest	None observed.
Lateral Movement	None observed.
Vertical Alignment	Good.
Horizontal Alignment	Good.
Condition at Abutment and at Concrete Structures	Good.
Indications of Movement of Structural Items on Slopes	Not applicable.
Trespassing on Slopes	Not applicable.
Sloughing or Erosion of Slopes or Abutments	Not applicable.
Rock Slope Protection - Riprap Failures	Not applicable.
Unusual Movement or Cracking at or Near Toes	Not applicable.
Unusual Embankment or Downstream Seepage	None observed.
Piping or Boils	None observed.
Foundation Drainage Features	Drain holes provided for hollow core.
Toe Drains	Not applicable
Instrumentation System	

PERIODIC INSPECTION CHECK LIST

PROJECT BETHLEHEM DAM DATE November 14, 1978

PROJECT FEATURE _____ NAME _____

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
OUTLET WORKS - GATE BUILDING	Abandoned gate house - extensive vandalism and trespassing.
a. Concrete and Structural	
General Condition	Fair to good.
Condition of Joints	Fair to good.
Spalling	Minor at outside pool elevation, assumed to be caused by ice.
Visible Reinforcing	None observed.
Rusting or Staining of Concrete	None observed.
Any Seepage or Efflorescence	None observed.
Joint Alignment	Good.
Unusual Seepage or Leaks in Gate Chamber	Concrete at main gate was eroded and leaking badly. Penstock gate was tight.
Cracks	None observed.
Rusting or Corrosion of Steel	Minimal.
b. Mechanical and Electrical	All mechanical and electrical apparatus at old gate house has been removed or rendered inoperable by vandalism. Gates are in closed position without on-site lifting mechanism
Air Vents	
Float Wells	
Crane Hoist	
Elevator	
Hydraulic System	
Service Gates	
Emergency Gates	
Lightning Protection System	
Emergency Power System	
Wiring and Lighting System in Gate Chamber	

PERIODIC INSPECTION CHECK LIST

PROJECT BETHLEHEM DAM DATE November 14, 1978

PROJECT FEATURE _____ NAME _____

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
OUTLET WORKS - CONDUIT	
General Condition of Concrete	Original 72" diameter steel penstock has been removed for scrap. Penstock gate is down and tight.
Rust or Staining on Concrete	
Spalling	
Erosion or Cavitation	
Cracking	
Alignment of Monoliths	
Alignment of Joints	
Numbering of Monoliths	

PERIODIC INSPECTION CHECK LIST

PROJECT BETHLEHEM DAM DATE November 14, 1978

PROJECT FEATURE _____ NAME _____

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
OUTLET CHANNEL	Energy dissipator, then natural channel. Signs of extensive ice jamming were observed on both downstream banks at elevations above the spillway crest, indicating a downstream pool is formed during ice jamming.
General Condition of Concrete	
Rust or Staining	
Spalling	
Erosion or Cavitation	
Visible Reinforcing	
Any Seepage or Efflorescence	
Condition at Joints	
Drain Holes	
Channel	
Loose Rock or Trees Overhanging Channel	
Condition of Discharge Channel	

PERIODIC INSPECTION CHECK LIST

PROJECT BETHLEHEM DAM DATE November 14, 1978

PROJECT FEATURE _____ NAME _____

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS	Not applicable - run-of-river dam.
a. Approach Channel	
General Condition	
Loose Rock Overhanging Channel	
Trees Overhanging Channel	
Floor of Approach Channel	
b. Weir and Training Walls	
General Condition of Concrete	
Rust or Staining	
Spalling	
Any Visible Reinforcing	
Any Seepage or Efflorescence	
Drain Holes	
c. Discharge Channel	
General Condition	
Loose Rock Overhanging Channel	
Trees Overhanging Channel	
Floor of Channel	
Other Obstructions	

PERIODIC INSPECTION CHECK LIST

PROJECT BETHLEHEM DAM DATE November 14, 1978

PROJECT FEATURE _____ NAME _____

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
OUTLET WORKS - INTAKE CHANNEL AND INTAKE STRUCTURE	Not applicable - run-of-river dam.
a. Approach Channel	
Slope Conditions	
Bottom Conditions	
Rock Slides or Falls	
Log Boom	
Debris	
Condition of Concrete Lining	
Drains or Weep Holes	
b. Intake Structure	
Condition of Concrete	
Stop Logs and Slots	

PERIODIC INSPECTION CHECK LIST

PROJECT BETHLEHEM DAM **DATE** November 14, 1978

PROJECT FEATURE _____ **NAME** _____

DISCIPLINE _____ **NAME** _____

AREA EVALUATED	CONDITION
OUTLET WORKS - SERVICE BRIDGE	Not applicable.
a. Super Structure	
Bearings	
Anchor Bolts	
Bridge Seat	
Longitudinal Members	
Under Side of Deck	
Secondary Bracing	
Deck	
Drainage System	
Railings	
Expansion Joints	
Paint	
b. Abutment and Piers	
General Condition of Concrete	
Alignment of Abutment	
Approach to Bridge	
Condition of Seat and Backwall	

PERIODIC INSPECTION CHECK LIST

PROJECT BETHLEHEM DAM DATE November 14, 1978

PROJECT FEATURE _____ NAME _____

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
RESERVOIR	
Stability of Shoreline	Generally good - some animal (beaver) habitation indicated on right upstream bank.
Sedimentation	Extensive sedimentation - average depth of impoundment is 2-5 feet.
Changes in Watershed Runoff Potential	
Upstream Hazards	None observed.
Downstream Hazards	None.
Alert Facilities	None observed.
Hydrometeorological Gages	None.
Operational and Maintenance Regulations	None known.

NOTE: Excessive sedimentation was found inside the dam core. It was determined through discussions with the former owner (Public Service) that the sediment is washed in through the drains during winter when a downstream pool is created by ice jamming. This could not be confirmed by the visual inspection and further investigation is recommended.

APPENDIX B

PROJECT RECORDS AND PLANS

1. Listing of Design, Construction and Maintenance Records:

    a. Construction Summary - May 25, 1927
    b. Specification Abstract - July 30, 1925

2. Copies of Past Inspection Reports:

    a. New Hampshire Water Resources Board - August 14, 1936
    b. New Hampshire Water Resources Board - July 18, 1974

3. Plan:

    a. Selected Details from Original Construction Drawings

Specifications for Dam, Headgates & Abutments,

Bethlehem Electric Co.

Bethlehem, N.H.

July 30, 1925

The work covered by this specification includes:

1. The building of a concrete and reinforced concrete dam in the Ammonoosuc River near Bethlehem Hollow, N. H.

2. The removal of old crib work and masonry, and the reconstruction of the present headgate structure.

3. The removal of the old crib work and the construction of new wing walls and embankments on the both ends of the dam.

4. The construction of a new wastegate on the right end of the dam.

5. The setting of all iron work, gate frames, anchor bolts, etc. required above.

6. All other work including coffer dam and pumping for excavation of foundation that may be a part of the above.

7. All extra work that may be ordered by the engineer from time to time.

All work is to be done in accordance with these specifications and substantially as shown on plan prepared by the engineer and numbered File 954-3, No. 1 dated May 21 and revised Aug. 1st 1925 which is hereby made a part of these specifications and under the supervision of the engineer.

Bethlehem, N. H.

Bethlehem Electric Company.

I-1682 Construction of dam on the Ammonoosuc River near Bethlehem Junction.

Ambursen type, concrete dam, built downstream adjacent to old log dam, the excavation for the concrete mat and core wall were carried down into earth material containing sufficient clay to insure a practically impervious sub-foundation.

The contractors began actual work in August 1925 and finished in February 1926; first concrete poured September 2, 1925; last, poured February 13, 1926.

Total elapsed time 165 days; total concrete 3855.5 cubic yards; average progress 23.36 cu. yds. per day.

Total days, cement poured 82; total cu. yds. poured 3855.5, average progress based on days poured 47.01 cu. yds. per day.

The south earth dike was completed during the season of 1926, scouring at the toe of the concrete apron progressed to such a point that it became necessary to provide protection; this was done by building a timber rock filled crib along the toe of the apron; a crib was also built along the river side of the penstock, this work was completed during November 1926.

References; Plans, D-1385; Correspondence, etc., I-1682; Daily Reports, Progress Views, Cement, sand, gravel and concrete tests and memoranda, see I-1682 Bethlehem Electric Co. ~~File H.~~

Samuel J. Lord

May 25, 1927.

SJL:GMG

NEW HAMPSHIRE WATER CONTROL COMMISSION

DATA ON WATER POWER DEVELOPMENTS IN NEW HAMPSHIRE

LOCATION AT DAM NO. 35.01

Town Bethlehem : County Grafton

Stream Lower Ammonoosuc River

Basin-Primary Conn R : Secondary Upper Ammonoosuc

Local Name

GENERAL DATA

Head-Max. 48' ft.: Min. 42 ft.: Ave. ft.

Date of Construction : Use of Power Public Utility

Pondage ac. ft.: Storage ac. ft.

DESCRIPTION

Racks

Size of Rack Opening

Size of Bar : Material

Area: Gross Sq. Ft.: Net sq. ft.

Head Gates

Type

Number : Size ft. high x ft. wide

Elevation of Invert : Total Area sq. ft.

Hoist

Penstock

Number 1 : Material (Penstock to Power House)

Size : Length 1000

Turbines

Number 1 : Makers S. Morgan Smith

Rating HP. per unit 660 H.P. : Total Capacity HP.

Max. Dement C.F.S., per unit : Total cfs.

Drive

Type

Generator

Number 1

Make G E

Rating KW., per unit ; Total Capacity 300 K. W.

Exciter

Number : Make

Rating-per unit : Total Capacity K. W.

OUTPUT—KWHRS

19.....	:	19.....	
19.....	:	19.....	
19.....	:	19.....	
19.....	:	19.....	
19.....	:	19.....	

OWNER Public Service Co. of N.H. Manchester N.H.

Date October 2 1939

1204

NEW HAMPSHIRE WATER CONTROL COMMISSION
DATA ON DAMS IN NEW HAMPSHIRE

LOCATION STATE NO. 35.01

Town Bethlehem : County Grafton

Stream Lower Ammonoosuc River

Basin-Primary Conn R : Secondary Ammonoosuc R.

Local Name

Coordinates—Lat. 44 15' +14,800 : Long. 71 40' -4600

GENERAL DATA

Drainage area: Controlled ..... Sq. Mi.: Uncontrolled ..... Sq. Mi.: Total 93 Sq. Mi.

Overall length of dam 500' ft.: Date of Construction 1925

Height: Stream bed to highest elev. 28' ft.: Max. Structure 17' ft.

Cost—Dam : Reservoir

DESCRIPTION Amburson Type-Concrete

Waste Gates

Type

Number 1 : Size 19' ft. High x 8' ft. wide

Elevation Invert : Total Area 152' sq. ft.

Hoist

Waste Gates Conduit

Number : Materials

Size ft.: Length ft.: Area sq. ft.

Embankment

Type

Height—Max. ft.: Min. ft.

Top—Width : Elev. ft.

Slopes—Upstream on : Downstream on

Length—Right of Spillway : Left of Spillway

Spillway

Materials of Construction Concrete

Length—Total ft.: Net 140' ft

Height of permanent section—max. 17 ft.: Min. ft.

Flashboards—Type : Height 4' ft

Elevation—Permanent Crest : Top of Flashboard

Flood Capacity 14,700 cfs.: 149 cfs/sq. mi.

Abutments

Materials: Concrete

Freeboard: Max. 9' ft.: Min. ft

Headworks to Power Devel.—(See "Data on Power Development")

OWNER Public Service Co of N.H. Manchester N.H

REMARKS Used for Public Utilities— Power

Tabulated ... Date ... 1939

PUBLIC SERVICE COMMISSION OF NEW HAMPSHIRE—DAM RECORD I-5444

TOWN	BETHLEHEM	TOWN NO. 1	STATE NO. 25
RIVER STREAM	Lower Ammonoosuc River		
DRAINAGE AREA	83	POND AREA	
DAM TYPE	Ambursen	FOUNDATION NATURE OF	Earth
MATERIALS OF CONSTRUCTION	Concrete		
PURPOSE OF DAM	POWER—CONSERVATION—DOMESTIC—RECREATION—TRANSPORTATION—PUBLIC UTILITY		
HEIGHTS, TOP OF DAM TO BED OF STREAM	Approx. 26'	TOP OF DAM TO SPILLWAY CRESTS	9'
SPILLWAYS, LENGTHS DEPTHS BELOW TOP OF DAM	140" 1 - Flood Gate 19' high8'wide		LENGTH OF DAM Approx.
FLASHBOARDS TYPE, HEIGHT ABOVE CREST	4'		
OPERATING HEAD CREST TO N. T. W.	42'	TOP OF FLASHBOARDS TO N. T. W.	46'
WHEELS, NUMBER KINDS & H. P.	1 - S. Morgan Smith - 460 HP		
GENERATORS, NUMBER KINDS & K. W.	1 - GE 300 KW		
H. P. 90 P. C. TIME 100 P. C. EFF.		H. P. 75 P. C. TIME 100 P. C. EFF.	
REFERENCES, CASES, PLANS, INSPECTIONS	I-1632		

REMARKS

OWNER: Public Service Co. of N.H.

CONDITION: Good

MENACE: Over 25'. Subject to periodic inspection.

To the Public Service Commission:

The foregoing memorandum on the above dam is submitted covering inspection made Aug. 14, 1936, according to notification to owner dated Aug. 5, 1936, and bill for same is enclosed.

D. Waldo White
Chief Engineer

Aug. 20, 1936
Copy to Owner

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NEW HAMPSHIRE WATER RESOURCES BOARD

INVENTORY OF DAMS AND WATER POWER DEVELOPMENTS

DAM

25.01

BASIN Connecticut NO. [illegible]
RIVER [illegible] MILES FROM MOUTH 33.1[illegible] D.A.-SQ.MI. [illegible]
TOWN [illegible] OWNER [illegible]
LOCAL NAME OF DAM
BUILT ______ DESCRIPTION [illegible]

POND AREA-ACRES ______ DRAWDOWN-FT. ______ POND CAPACITY-ACRE FT. ______
HEIGHT-TOP TO BED OF STREAM-FT. [illegible] MAX. ______ MIN.
OVERALL LENGTH OF DAM-FT. [illegible] MAX.FLOOD HEIGHT ABOVE CREST-FT. ______
PERMANENT CREST ELEV.U.S.G.S. [illegible].6 LOCAL GAGE ______
TAILWATER ELEV.U.S.G.S. 10[illegible].3 LOCAL GAGE ______
SPILLWAY LENGTHS-FT. [illegible] FREEBOARD-FT. 0
FLASHBOARDS-TYPE,HEIGHT ABOVE CREST [illegible]
WASTE GATES-NO. WIDTH MAX. OPENING DEPTH SILL BELOW CREST

REMARKS [illegible]
[illegible]
Max high water [illegible]
SD [illegible] Top [illegible] El. 1116.4

POWER DEVELOPMENT

UNITS NO.	RATED HP.	HEAD FEET	C.F.S. FULL GATE	KW.	MAKE
1	[illegible]	[illegible]			[illegible]
1	[illegible]	46	USGS	[illegible]	General Electric
				P.S. [illegible]	
	4[illegible]	46.3	AE		

USE Power

REMARKS 1000 ft. [illegible] to Power House

DATE [illegible]

N. H. WATER RESOURCES BOARD
Concord, N. H. 03301

DAM SAFETY INSPECTION REPORT FORM

Town: Bethlehem Dam Number: 25.01

Inspected by: SOB Date: 18 July 1974

Local name of dam or water body: _____

Owner: Arnold Polanski Address: _____

Owner was/was not interviewed during inspection.

Drainage Area: _____ sq. mi. Stream: _____

Pond Area: _____ Acre, Storage _____ Ac-Ft. Max. Head ~~4.5~~ 2.6 Ft.

Foundation: Type _____, Seepage present at toe - Yes/No, _____

Spillway: Type Over Flow, Freeboard over perm. crest: -9,

Width 149, Flashboard height _____,

Max. Capacity _____ c.f.s.

Embankment: Type _____, Cover _____ Width _____,

Upstream slope _____ to 1; Downstream slope _____ to 1

Abutments: Type _____, Condition: Good, Fair, Poor

Gates or Pond Drain: Size 19' x 8' Capacity _____ Type Gate

Lifting apparatus _____ Operational condition ?

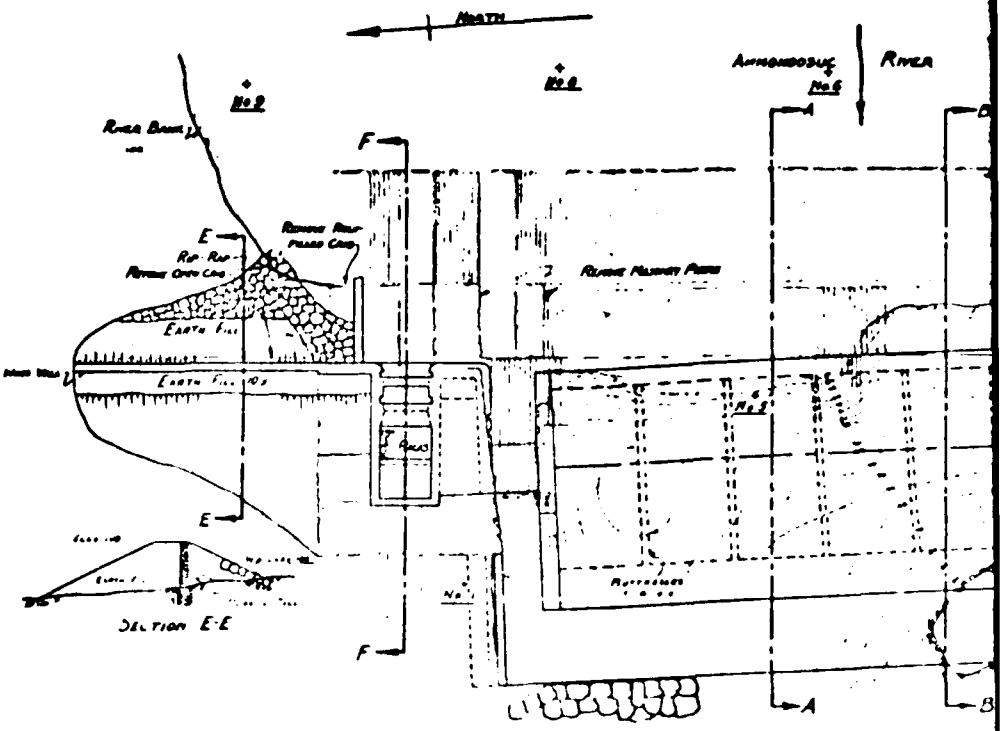
Changes since construction or last inspection: _____

Downstream development: _____

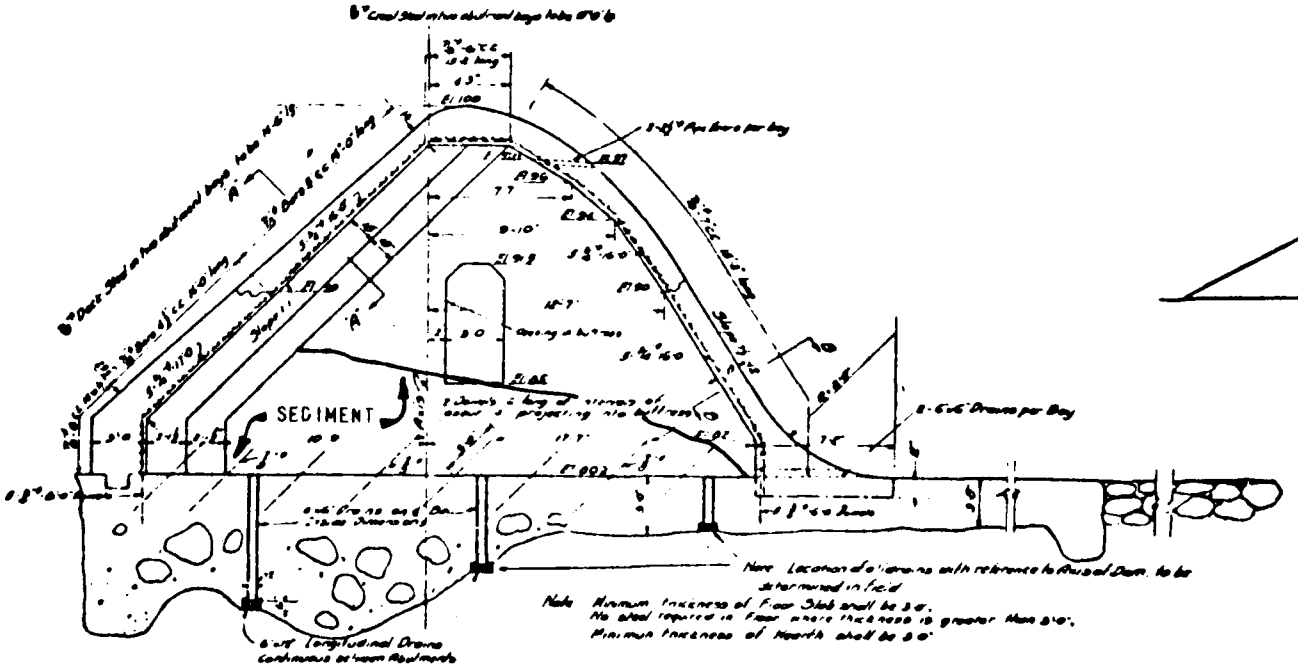
This dam would/would not be a menace if it failed.

Suggested reinspection date: _____

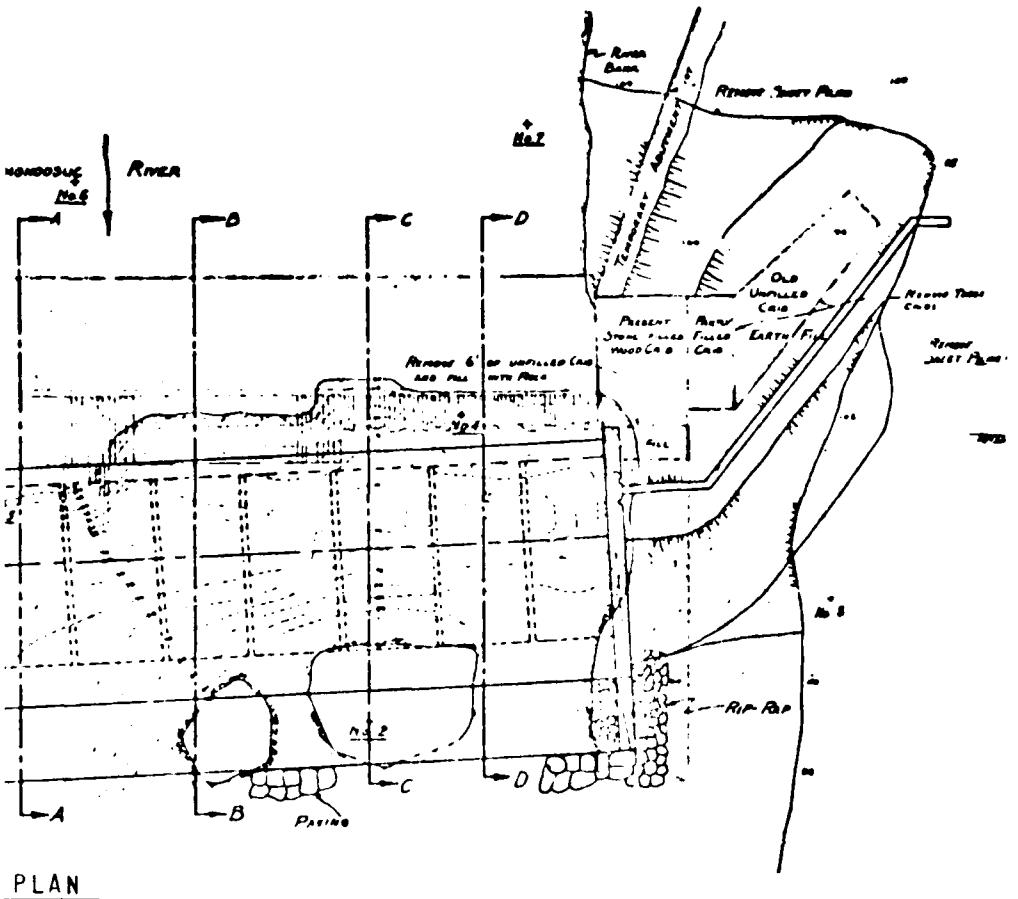
Remarks: Not Used For Power Gate Not work'
Concrete around Gate loose cracked



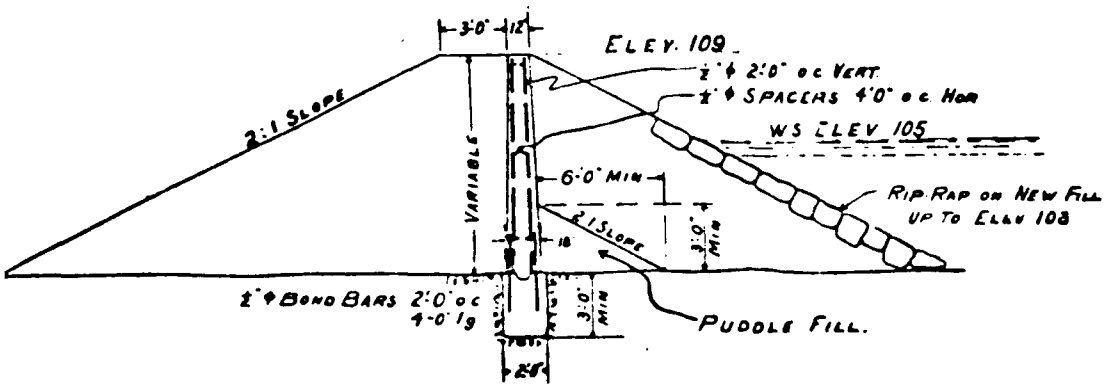
PLAN



TYPICAL SECTION THROUGH SPILLWAY SHOWING DECK APRON & FLOOR REINFORCEMENT



PLAN



TYPICAL EMBANKMENT SECTION

INFORCEMENT

[illegible]	U.S. ARMY ENGINEER DIV. NEW ENGLAND

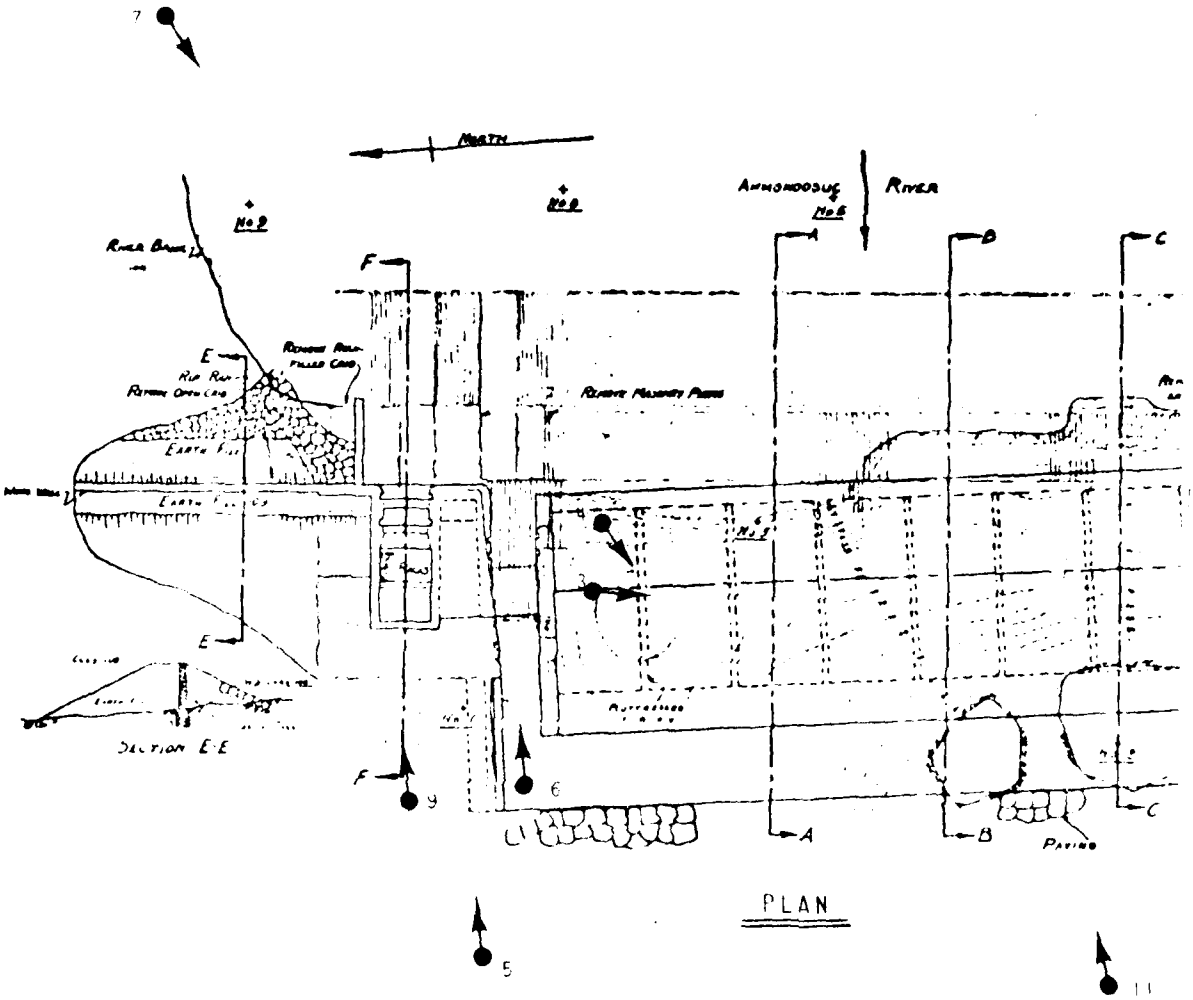
NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

BETHLEHEM DAM
SELECTED DETAILS
FROM
CONSTRUCTION DRAWINGS

CLIENT NO.	04-0087		SCALE N.T.S.
ENGR.	JAD		DATE

APPENDIX C

PHOTOGRAPHS



PLAN

PHOTO L
AND NUM

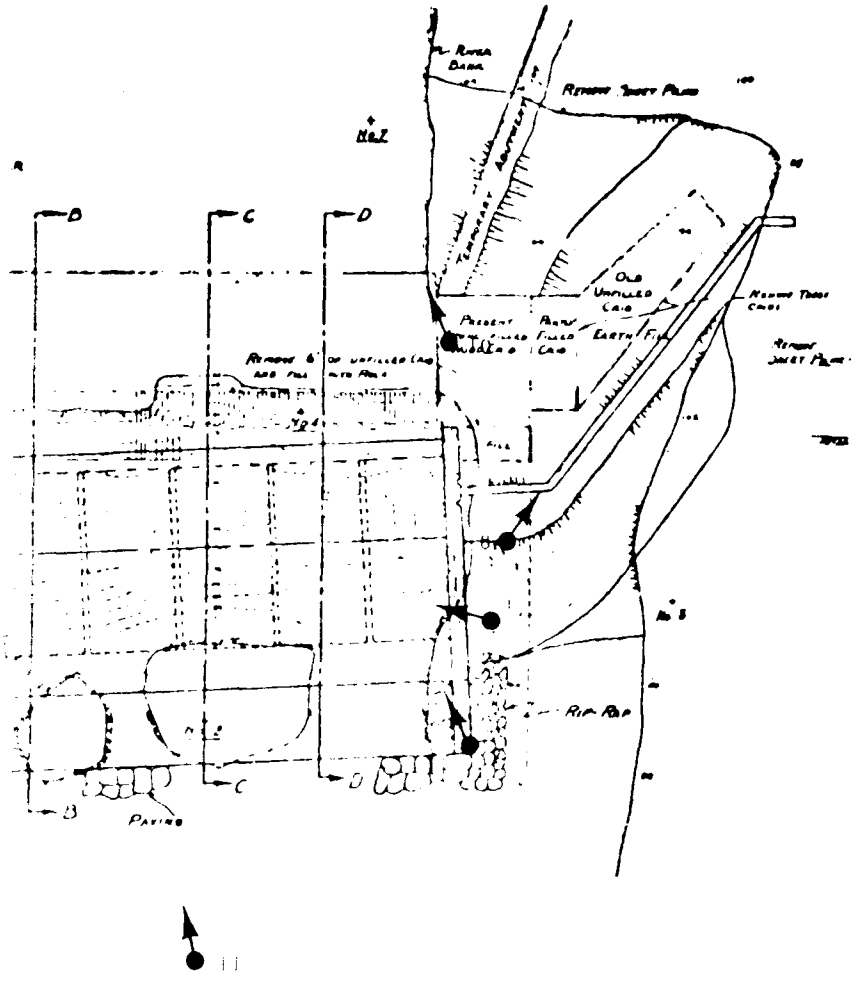


PHOTO LOCATION AND NUMBER

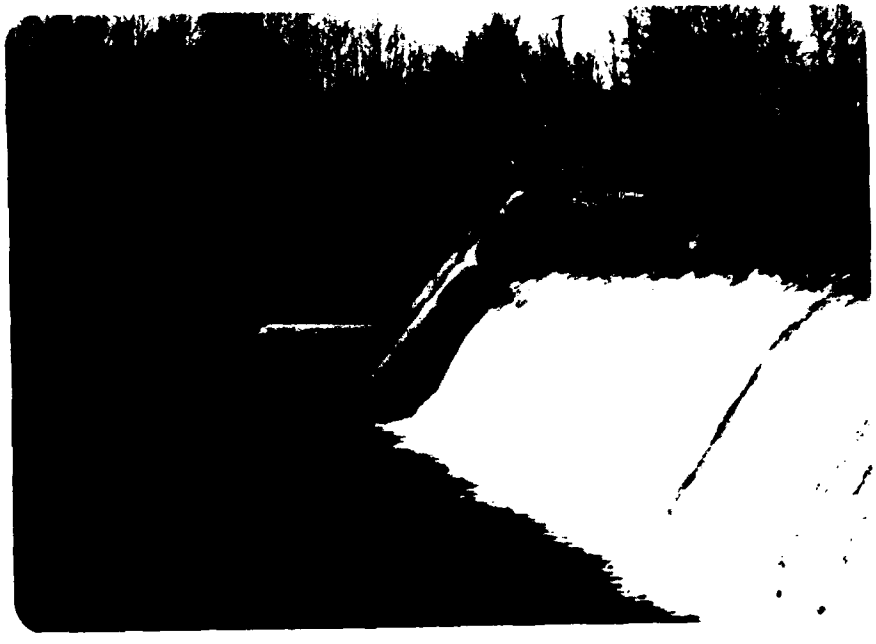
DUFRESNE-HENRY ENGINEERING CORP. ARCHITECT-ENGINEER	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

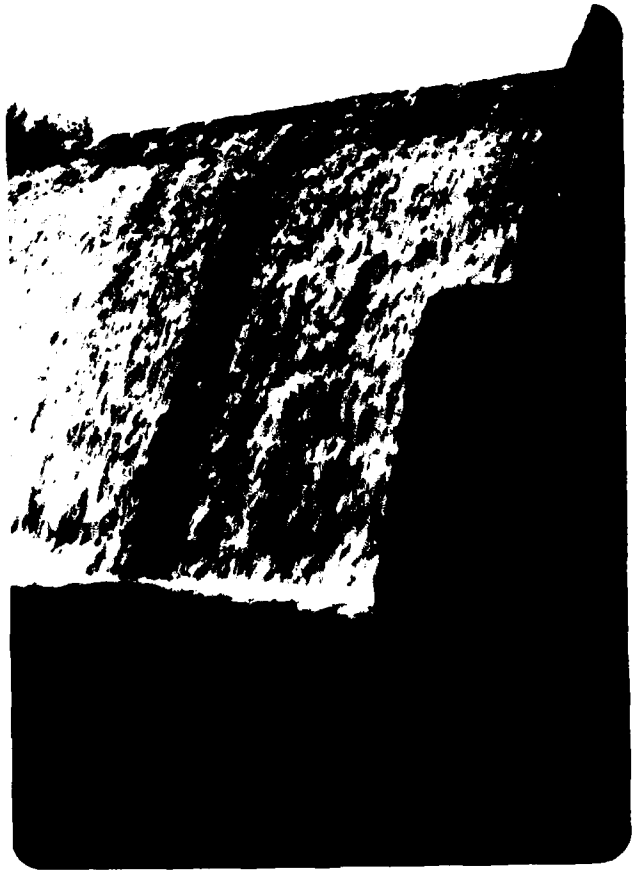
BETHLEHEM DAM

PHOTO LOCATION PLAN

CLIENT NO.	04-0087		SCALE N.T.S.
ENGR.	JAD		DATE



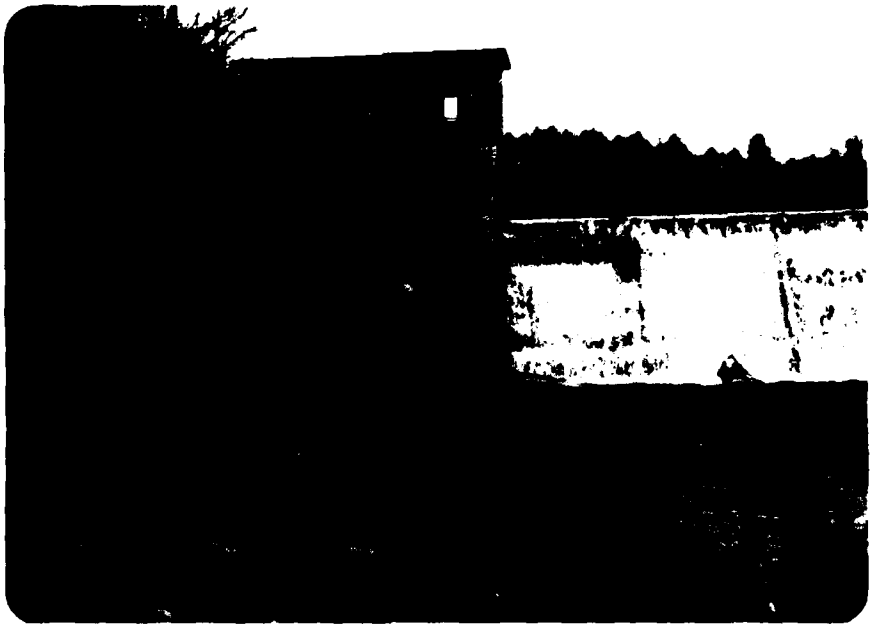
#1. VIEW OF SPILLWAY AND GATE WORKS



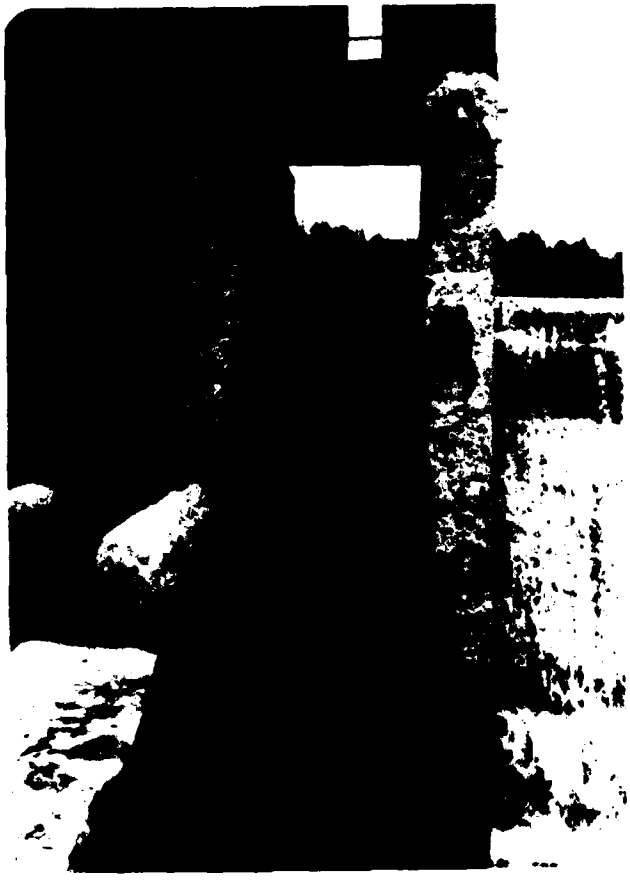
#2. VIEW OF LEFT SIDE SPILLWAY SHOWING ERODED JOINT

#3. VIEW OF DAM INTERIOR SHOWING WALKWAY AND SEDIMENT BUILDUP

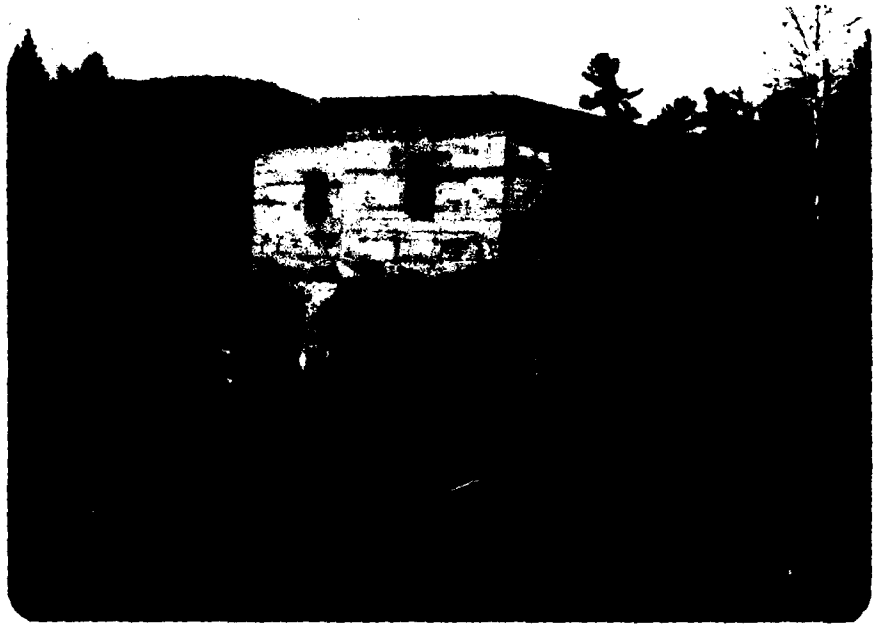
#4. VIEW OF DOWNSTREAM SIDE OF FIRST COMPARTMENT (RIGHT SIDE)



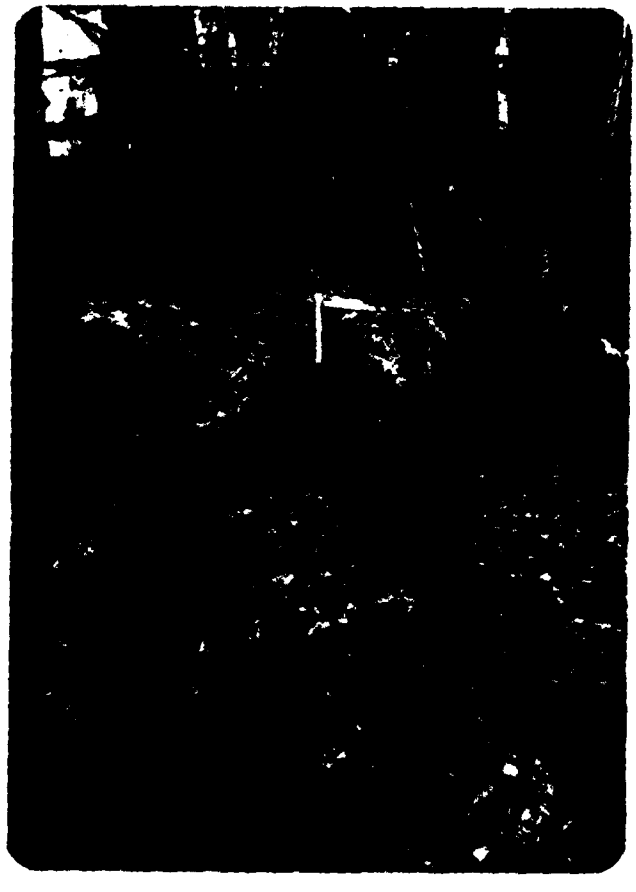
#5. VIEW OF GATE WORKS AND RIGHT SIDE SPILLWAY



#6. VIEW OF WASTE GATE AND SLUICEWAY



#7. UPSTREAM VIEW OF GATE WORKS AND CORE WALL



#8. VIEW OF LEFT CORE WALL

#9. VIEW OF OLD PENSTOCK SECTION

#10. GENERAL VIEW OF UPSTREAM RESERVOIR

#11. VIEW OF DOWNSTREAM CHANNEL

#12. OVERHEAD VIEW OF DAM, UPSTREAM AND DOWNSTREAM CHANNELS

APPENDIX D

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

DUFRESNE-HENRY ENGINEERING CORPORATION

E J. DOHRMAN SUBJECT BETHLEHEM DAM
DATE AREA - STORAGE ESTIMATES
SHEET NO. ____ OF ____
JOB NO. ____

SIZE AND STORAGE ESTIMATE

NORMAL LENGTH = 1700 FEET (ESTIMATED FROM AERIAL PHOTOGRAPH)

AVERAGE WIDTH = 140 FEET (ESTIMATED FROM AERIAL PHOTOGRAPHS

AVERAGE DEPTH = 4 FEET

NORMAL IMPOUNDMENT AREA = 1700 × 140 = 238,000 FT²
= 5.46 ACRES
STORAGE = 21.8 AC-FEET

MAXIMUM POOL IMPOUNDMENT

ASSUME LENGTH INCREASES TO 2800 FEET
WIDTH REMAINS 140 FEET

ESTIMATE DEPTH = 4' + 9' = 13 FEET

MAX. POOL AREA = 2800 × 140 = 392,000 = 8.99 AC

MAX. STORAGE = 8.99 × 13 = 116 AC-FEET

DUFRESNE-HENRY ENGINEERING CORPORATION

BY W. A. LEONARD SUBJECT BETHLEHEM DAM SHEET NO. 1 OF 4
DATE 3-6-79 DRAINAGE AREA – CLASSIFICATION JOB NO. 04-0087

DRAINAGE AREA: FROM WATER RESOURCES, DRAINAGE AREA FOR THE GAGING STATION IS 87.6 MI.^{2}
NEED TO ADD DRAINAGE AREA FROM THERE TO DAM GAUGE NO. 01137500
DEEP JUNCTION

PLANIMETER READING, 8.72

SCALE 1:62,500
FACTOR = .97304 (8.72)(.97304) = 8.48

8.48 + 87.6 = 96.1 SQ MI

DAM CLASSIFICATION:

SIZE: HEIGHT 29'
STORAGE 116 AC-FEET
SMALL

HAZARD
HOUSES DOWNSTREAM ARE NOT WITHIN FLOOD PLAIN
LOW

DUFRESNE-HENRY ENGINEERING CORPORATION

BY W.A. LEONARD SUBJECT BETHLEHEM DAM SHEET NO. 2 OF 4
DATE 3-7-79 TEST FLOOD SELECTION & COMPS JOB NO. 04-0087

FOR SMALL DAM WITH LOW HAZARD

TEST FLOOD 50-100yr FREQ FLOOD

FROM COMPUTER RUN 100yr FLOOD = 15,973 cfs
(OUTFLOW FLOW FIGURE TAKEN AT BETHLEHEM GAGING STATION)

DISCHARGE VALUES FOR SPILLWAY
SPILLWAY CREST ELEV 100
ELEV OF WING WALLS 105

$Q = CLH^{3/2}$ $L = 140$

DESIGN $h = 7'$
C VALUES FROM "ANDERSON ... HYDRAULICS" FIG 5.22.1

$h = 0$ $Q = 0$

$h = 1$ $Q = (3.8)(3.0)(140)(1)^{3/2} =$ 452.4 cfs

$h = 2$ $Q = (3.8)(3.0)(140)(2)^{3/2} =$ 1359 cfs

$h = 3$ $Q = (3.88)(3.0)(140)(3)^{3/2} =$ 2554 cfs

$h = 4$ $Q = (3.99)(3.0)(140)(4)^{3/2} =$ 4062 cfs

$h = 5$ $Q = (3.97)(3.0)(140)(5)^{3/2} =$ 5,804.0 cfs

$h = 6$ $Q = (3.96)(3.0)(140)(6)^{3/2} =$ 7,744.4 cfs

$h = 7$ $Q = (4.0)(3.0)(140)(7)^{3/2} =$ 10,112 cfs

$h = 8$ $Q = (4.03)(3.0)(140)(8)^{3/2} =$ 12,775 cfs

$h = 9$ $Q = (4.06)(3.0)(140)(9)^{3/2} =$ 15,479 cfs

$h = 9.5$ $Q = (4.07)(3.0)(140)(9.5)^{3/2} =$ 17,166.0
$+ \quad 2.5(2)(1)^{3/2} =$ 5.0
TOTAL = 17,171 cfs

$h = 9.1$ $Q = (4.06)(3.0)(140)(9.1)^{3/2} =$ 15,638
$+ \quad 2.5(.1)(14)(.1)^{3/2} =$ 11
TOTAL = 15,649 cfs

DUFRESNE-HENRY ENGINEERING CORPORATION

BY W.A. LEONARD SUBJECT BETHLEHEM DAM SHEET NO. 3 OF 4
DATE 3-7-79 TEST FLOOD ROUTE JOB NO. 04-038M

h= 9.2 $Q = 1.05(3.9)(140)(9.2)^{3/2} = 15998.$
$+ \quad 2.5(.2)(145)(.2)^{1/2} = 32$
TOTAL 16330 cfs

100 year flow at gaging station = 15,973

Flow at Dam = $\left(\frac{\text{Drainage}}{\text{Drainage at gaging station}}\right)^{.6}$ (100 yr flow at gaging sta

.6 = Recommended for Appalachian Plateau Physiographic Section

$Q_{100 \text{ @ Dam}}$ $\left(\frac{26.1}{87.6}\right)^{.6}(15,973) =$ [illegible]

∴ Test Flow At Dam = 16,[illegible] cfs

DUFRESNE-HENRY ENGINEERING CORPORATION

BY W.A.L SUBJECT BETHLEHEM DAM SHEET NO. ____ OF ____
DATE 6-1-79 DAM FAILURE ANALYSIS JOB NO. 04-00.37

DAM FAILURE ANALYSIS

NORMAL CONDITIONS — WATER LEVEL @ SPILLWAY CREST ELEVATION

STREAMBED ELEV = 80.0
SPILLWAY CREST ELEV = 100.0

Y_o = 20' LENGTH = 140' (SPILLWAY)

$Q = C_{2/3} W_b \sqrt{g}\, Y_o^{3/2} = C_{2/3}(.4)(140)\sqrt{32.2}\,(20)^{3/2} =$ 5171 cfs

INITIAL FLOW WIDTH = 2/3 (20) = 13.2'
BANKS ARE 20' HIGH — NO OVERBANK FLOW

"TOP OF DAM" CONDITIONS — WATER LEVEL @ TOP OF ABUTMENTS (ELEV 120)

SINGLE 10B Y_o = 28
WIDTH OF SPILLWAY = 140
WIDTH OF BREACH = (.4)(140) = 56'

DISCHARGE REQUIRED TO BE AT TOP OF DAM = 18,710 cfs
DISCHARGE THRU BREACH = $Q = C_{2/3} W_b \sqrt{g}\,(Y_o)^{3/2} = C_{2/3}(56)\sqrt{32.2}\,(28)^{3/2} =$ 13,527
DISCHARGE OVER REMAINING SPILLWAY = CLW$^{3/2}$ = $3.9(.6)(140)^{3/2}$ = 7,913

TOTAL FAILURE FLOW = 13,900 + 7,913 = 21,813 cfs
INCREASE DUE TO FAILURE = 21,363 − 13,700 = 8,113 cfs

HYDRAULIC CAPACITY OF BREACH = $Q = 3.08\,(56)\,H^{3/2}$

$$H = \left(\frac{13,700}{(3.08)(56)}\right)^{2/3} = 17.8$$

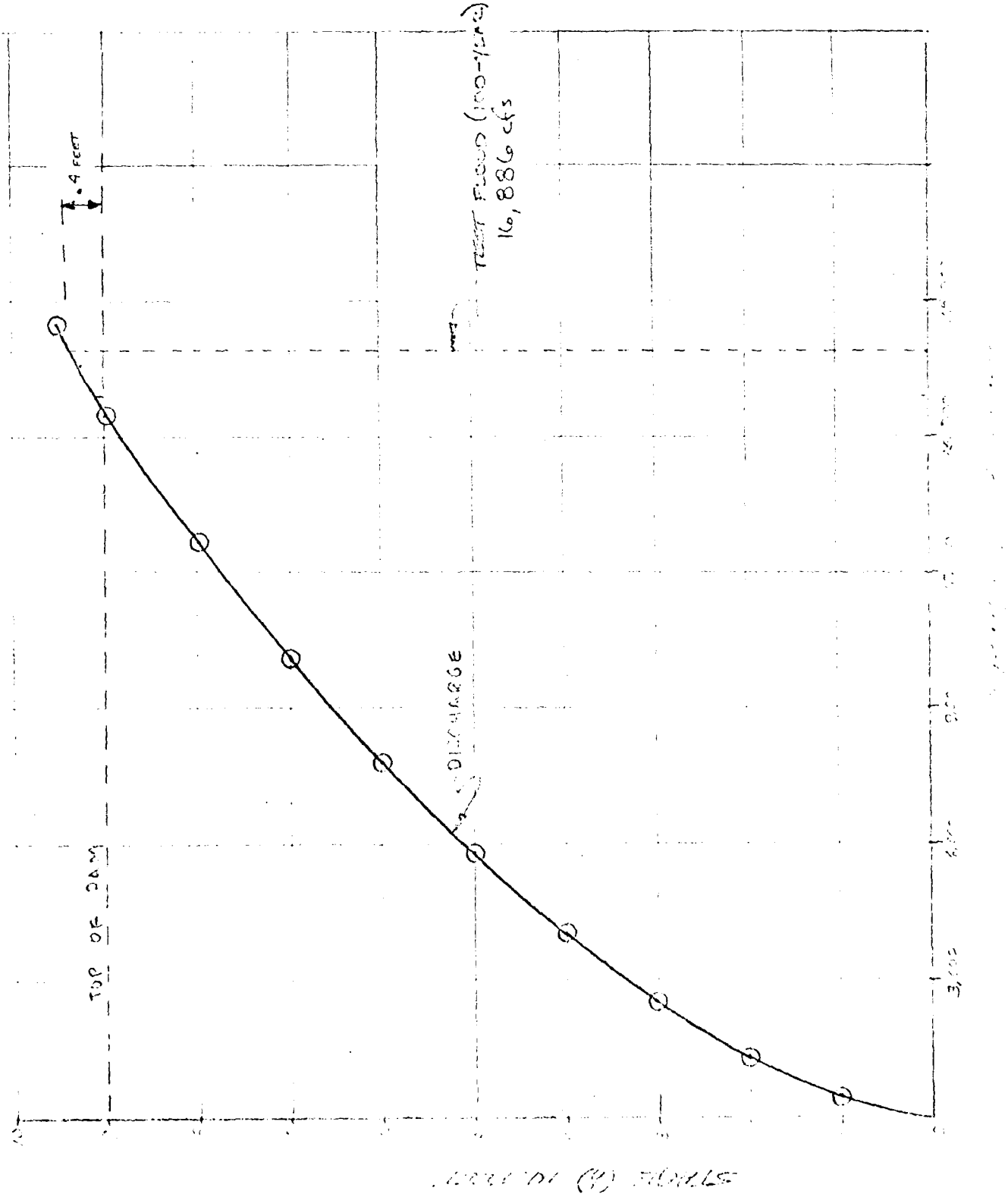
STAGE BEHIND DAM DROPS TO (100 + 17.8) = 917.8

VOLUME RELEASED = 116 − 20 = 96 ACRE-FEET

DUFRESNE-HENRY ENGINEERING CORPORATION

BY W.A. LOVELL SUBJECT [illegible] DAM SHEET NO. 4 OF 4

DATE 3-17-'15 STAGE VS. DISCHARGE JOB NO. [illegible]



FLOOD FLOW FREQUENCY COMPUTATION

01137500 AMMONOOSUC RIVER AT BETHLEHEM JUCTION, NEW HAMPSHIRE

N	NSK	NOUTL	IYRA	IPLOT	IEXPP	SKEW	A	B	PRELM
38	0	0	1940	1	1	0.500	0.0	0.0	0.0

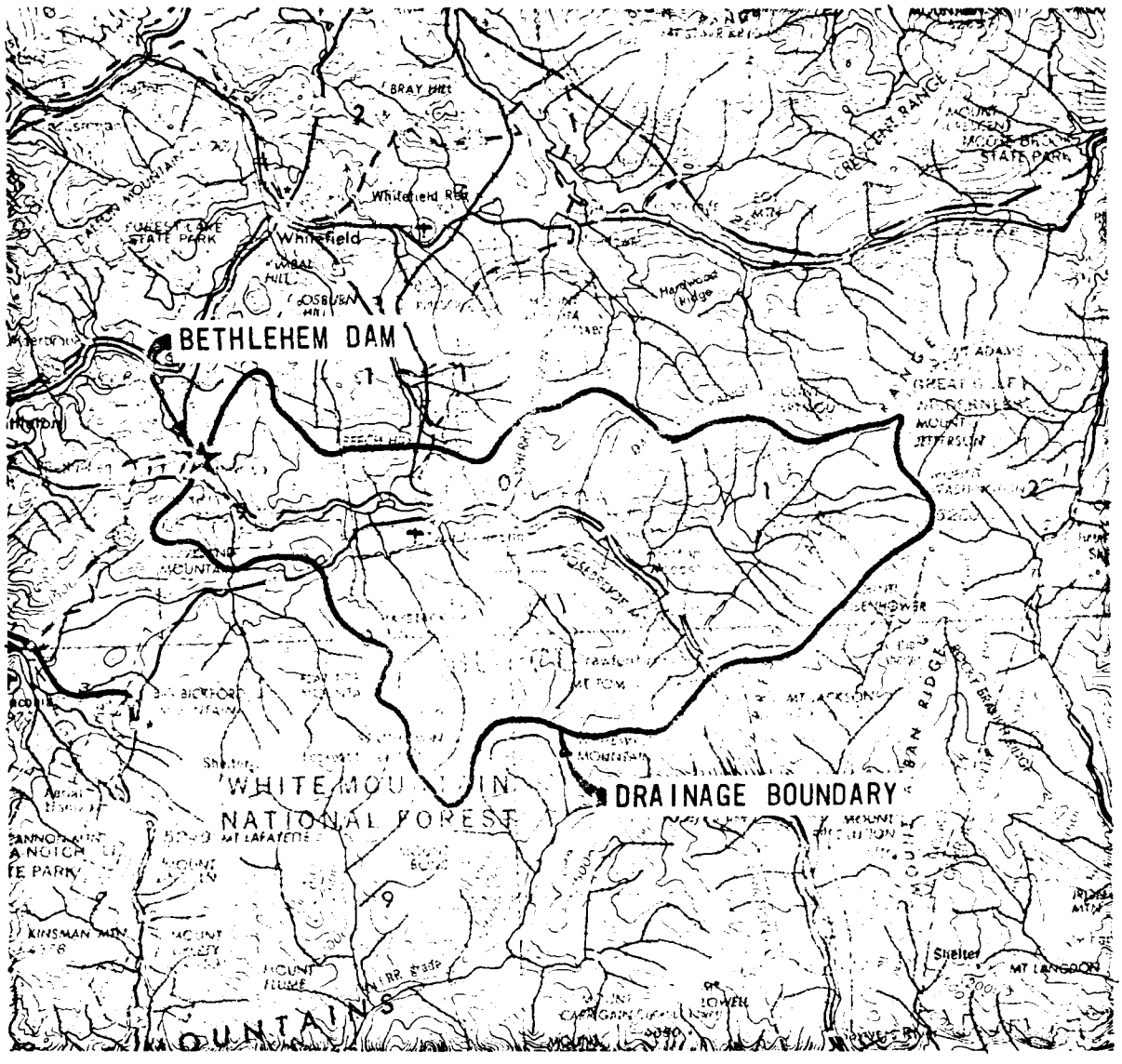
MEAN	3.6273
STD DEV	0.2036
COMPUTED SKEW	0.3723
REGIONAL SKEW	0.5000
ADOPTED SKEW	0.4779

COMPUTED FLOW	EXPECTED-PROBABILITY FLOW	PROBABILITY	.05 LIMIT	.95 LIMIT
21954.	21770.	0.002	31456.	15906.
17184.	17220.	0.005	24549.	13370.
14410.	15073.	0.010	20161.	11634.
12318.	13139.	0.020	16389.	10036.
10258.	10717.	0.040	13148.	8555.
7941.	8023.	0.100	9553.	6740.
6191.	6251.	0.200	7265.	5427.
4135.	4235.	0.500	4549.	3615.
2866.	2945.	0.800	3276.	2436.
2425.	2490.	0.900	2808.	2006.
2132.	2036.	0.950	2501.	1724.
1714.	1545.	0.990	2063.	1329.

FLOW IN CUBIC FEET PER SECOND

FINAL RESULTS

DAY	MONTH	YEAR	FLOW	ORDERED	RANK	PLOT POS
0	0	1940	5620.	10000.	1	0.0256
0	0	1941	2500.	10000.	2	0.0513
0	0	1942	2010.	9270.	3	0.0769
0	0	1943	3520.	8670.	4	0.1026
0	0	1944	5680.	8410.	5	0.1282
0	0	1945	2710.	8300.	6	0.1538
0	0	1946	4490.	8110.	7	0.1795
0	0	1947	3500.	6040.	8	0.2051
0	0	1948	3470.	5750.	9	0.2308
0	0	1949	3230.	5680.	10	0.2564
0	0	1950	6340.	5620.	11	0.2821
0	0	1951	8540.	5510.	12	0.3077
0	0	1952	5510.	5440.	13	0.3333
0	0	1953	8270.	5200.	14	0.3590
0	0	1954	8900.	4620.	15	0.3846
0	0	1955	3210.	4510.	16	0.4103
0	0	1956	3750.	4160.	17	0.4359
0	0	1957	2280.	4070.	18	0.4615
0	0	1958	6110.	3970.	19	0.4872
0	0	1959	2400.	3540.	20	0.5128
0	0	1960	10000.	3340.	21	0.5385
0	0	1961	2510.	3750.	22	0.5641
0	0	1962	2550.	3620.	23	0.5897
0	0	1963	3470.	3550.	24	0.6154
0	0	1964	4820.	3550.	25	0.6410
0	0	1965	4040.	3470.	26	0.6667
0	0	1966	1910.	3230.	27	0.6923
0	0	1967	5240.	3210.	28	0.7179
0	0	1968	5960.	2810.	29	0.7436
0	0	1969	3550.	2710.	30	0.7692
0	0	1970	5440.	2610.	31	0.7949
0	0	1971	2440.	2600.	32	0.8205
0	0	1972	2540.	2550.	33	0.8462
0	0	1973	10600.	2540.	34	0.8718
0	0	1974	3410.	2440.	35	0.8974
0	0	1975	4910.	2400.	36	0.9231
0	0	1976	4100.	2230.	37	0.9487
0	0	1977	3410.	1840.	38	0.9744



SOURCE OF MAP:
U.S. GEOLOGICAL QUADRANGLE
LEWISTON, ME., N.H., VT.
SERIES V501
1:250,000 REV. 1972

DUFRESNE-HENRY ENGINEERING CORP. ARCHITECT-ENGINEER	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

DRAINAGE AREA MAP
BETHLEHEM DAM

BETHLEHEM NEW HAMPSHIRE

CLIENT NO	04-0087		SCALE 1" = 4 MILES
ENGR	JAD		DATE

APPENDIX E

Information as Contained in the National Inventory of Dams

INVENTORY OF DAMS IN THE UNITED STATES

STATE	IDENTIFICATION NUMBER	DIVISION	STATE	COUNTY	CONGR DIST.	STATE	COUNTY	CONGR DIST.	NAME	LATITUDE (NORTH)	LONGITUDE (WEST)	REPORT DATE DAY	MO	YR
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				BETHLEHEM DAM	4417.4	7139.0	[illegible]	APR	79

POPULAR NAME	NAME OF IMPOUNDMENT
	AMMONOOSUC RIVER

REGION/BASIN	RIVER OR STREAM	NEAREST DOWNSTREAM CITY-TOWN-VILLAGE	DIST FROM DAM (MI.)	POPULATION
[illegible]	AMMONOOSUC RIVER	BETHLEHEM	0	1142

TYPE OF DAM	YEAR COMPLETED	PURPOSES	STRUCTURAL HEIGHT (FT.)	HYDRAULIC HEIGHT (FT.)	IMPOUNDING CAPACITIES MAXIMUM (ACRE-FT.)	IMPOUNDING CAPACITIES NORMAL (ACRE-FT.)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1922	D	29	29	114	22	FED	N	N	N	N

1ST DAM FED N PRV/SEC SEC N SEA/DATE 06APR79

REMARKS
21=FLOOD CONTROL 22=REPLACEMENT 2a=27=ESTIMATED 23=UNUSED

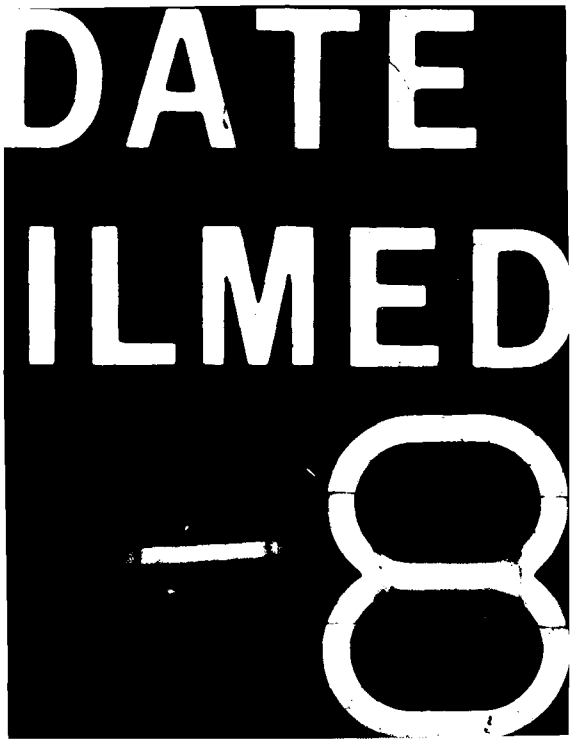
DAM'S MAS	SPILLWAY CREST LENGTH	SPILLWAY TYPE	SPILLWAY WIDTH (FT.)	MAXIMUM DISCHARGE (FT.)	VOLUME OF DAM (CY)	POWER CAPACITY INSTALLED (MW)	POWER CAPACITY PROPOSED (MW)	NAVIGATION LOCKS NO.	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4900											

OWNER	ENGINEERING BY	CONSTRUCTION BY
[illegible]	HOWARD M TURNER	ANDRUSS CONST COMPANY

REGULATORY AGENCY			
DESIGN	CONSTRUCTION	OPERATION	MAINTENANCE
[illegible]	[illegible]	FHWA	[illegible]

INSPECTION BY	INSPECTION DATE DAY	MO	YR	AUTHORITY FOR INSPECTION
[illegible]	[illegible]		79	PL92-367 AUGUST 8 1972

REMARKS
[illegible] GATES INOPERABLE


DATE
ILMED
-8